MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 3, 2022/2023 (T2260)**

## EEE7216 – ENGINEERING OPTIMIZATION

6 OCTOBER 2023

9:00 A.M. – 12:00 P.M.

(3 Hours)

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**INSTRUCTIONS TO STUDENTS:**

1. This question paper consists of **6** pages with **4** questions only (including this page).
2. Attempt ALL questions. Distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided. Show all relevant steps to obtain maximum marks. Submit the softcopy of the Excel worksheets used in calculations. Name the worksheets according to the question that you have answered, e.g. Question 1a, Question 1b etc.
4. Several formulas are provided in the **Appendix** for your reference

## Question 1

(a) Consider the following unconstrained optimization problems:

$$\text{Maximize } f(x) = 42x^3 + 3.5x - 60x^4 - 16.5x^2$$

Approximate the solution by using the golden search method, with an error tolerance $\epsilon = 0.001$ and initial bound [0, 0.5].

[10 marks]

(b) ABC Electric Company manufactures two types of electric lamps: type $A$ and type $B$. The price per unit of lamp type $A$ is \$50, and of lamp type $B$ is \$70. The lamp manufacturing machine is pretty old. Thus, the operating cost differs depend on the total production volume, with the operating cost per unit is \$5 for the first 50 units, \$3.50 for the subsequent 50 units, and \$3 for units 100 and over.

The demand for lamps is influenced by the amount (in \$) spent on advertisement for that particular lamp, with the equations as follows:

$$150 - \frac{1000}{10 + y_1} = \text{Number of units of type } A \text{ lamp demanded,}$$

$$250 - \frac{2000}{10 + y_2} = \text{Number of units of type } B \text{ lamp demanded,}$$

where $y_1$ is the amount (in \$1000) spent on advertisements for type $A$ lamp, and $y_2$ is the amount (in \$1000) spent on advertisements for type $B$ lamp.

ABC Electric Company management is committed to meeting demand while also maximizing the profit from the sales. The maximum production capacity for type $A$ and type $B$ lamps is 125 and 175 units, respectively. How many units of lamp should the ABC company produce, and how should the advertisement be allocated?

Formulate the above as nonlinear programming, and use the Excel Solver to solve the problems.

[15 marks]

**Continued...**

## Question 2

ABC Logistic Company delivers goods by truck from four warehouses to four distribution centers. The table below summarizes the transportation costs per truckload on the various routes (in $). You are required to determine the most cost-effective transporting schedule between the warehouse and the distribution hubs.

| | Distribution Center | | | |
|---|---|---|---|---|
| **Warehouse** | **1** | **2** | **3** | **4** |
| **A** | 64 | 65 | 66 | 50 |
| **B** | 69 | 84 | 92 | 57 |
| **C** | 48 | 45 | 23 | 50 |
| **D** | 59 | 34 | 30 | 52 |

(a) Design a genetic algortihm that can be used to determine an optimal plan, with one truckload from one warehouse to one distribution center, which will result in a minimum total transporting cost. Find the approximate solution by performing your proposed genetic algorithm up to *2 iterations* only.

Show the detail work in each iteration in your discussion, and include details on the following:

(i) Suggest a way to represent the individual as chromosome.
(ii) Generate an initial population for a population size of $n$ (set the value of $n$ yourself)
(iii) State the criteria used to select the parents, to create the children, and to form the new population.
(iv) Both crossover and mutation operators must be included in your proposed algorithm.

[10 marks]

(b) Develop a programming model to represent this problem, and solve the problem using Excel Solver.

[15 marks]

**Continued...**

## Question 3

Given the dataset on the monthly sales record of a product (in 1000 units) from Year 2012 to Year 2014.

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| **Jan** | 55 | 73 | 77 |
| **Feb** | 65 | 63 | 74 |
| **Mar** | 61 | 63 | 70 |
| **Apr** | 48 | 67 | 65 |
| **May** | 54 | 53 | 69 |
| **Jun** | 49 | 50 | 59 |
| **Jul** | 44 | 50 | 64 |
| **Aug** | 54 | 55 | 62 |
| **Sep** | 75 | 91 | 100 |
| **Oct** | 75 | 81 | 94 |
| **Nov** | 82 | 84 | 86 |
| **Dec** | 60 | 78 | 83 |

(a) Apply the Holt's method to estimate the sale in January of Year 2015. In your work, set the smoothing constants as $\alpha = 0.1$, and $\beta = 0.3$. Use appropriate initial value for trend and level in your work. [5 marks]

(b) (i) Use the data in Year 2012 and Year 2013, to calculate the initial level, trend and seasonal factors for prediction of sales record in Year 2014. These initial values are to be used in Winter's method to set up a one-month ahead forecasting model to forecast the sales values in Year 2014. In your calculation, you may choose the appropriate formulas to be used. [6 marks]

(ii) Based on the calculated level, trend, and seasonal factors obtained in part (i), set up an optimization model to determine the optimal smoothing constants to be used in forecasting the 12-month sales in Year 2014. The objective function used in the optimization model is to minimize the total mean absolute deviations (MAD) in the prediction of Year 2014. [8 marks]

(iii) Based on the initial values, and the optimal smoothing constants obtained in (i) and (ii), predict the sales records from January to April in Year 2015. [6 marks]

**Continued...**

## Question 4

The following dataset containing information about various attributes factors ($x_1$, $x_2$ and $x_3$) correspond to the output $y$.

| $x_1$ | $x_2$ | $x_3$ | $y$ |
|---|---|---|---|
| 417 | 847 | 426 | 1280 |
| 473 | 518 | 317 | 1054 |
| 467 | 456 | 354 | 1368 |
| 371 | 156 | 279 | 1091 |
| 458 | 190 | 213 | 874 |
| 385 | 9 | 188 | 645 |
| 465 | 260 | 207 | 773 |
| 390 | 333 | 196 | 807 |
| 509 | 1003 | 449 | 1716 |
| 496 | 1347 | 404 | 1796 |
| 530 | 276 | 307 | 1519 |
| 442 | 1596 | 346 | 1602 |
| 431 | 84 | 408 | 1584 |
| 469 | 579 | 288 | 1408 |
| 649 | 246 | 306 | 1421 |
| 415 | 175 | 256 | 1142 |
| 467 | 125 | 201 | 920 |

(a) You would like to identify the potential attributes factors ($x_1$, $x_2$ and $x_3$) that could influence the output $y$ linearly.

(i) Sketch the scatter plots for each independent variable versus the dependent variable. [6 marks]

(ii) Calculate the Pearson's correlation coefficient. Discuss the strength of the correlation of each independent variable to the dependent variable. [6 marks]

(b) Based on the results in part (a), select the independent variables with the highest strength in linear correlation with $y$. Then, find the respective linear regression equation. [6 marks]

(c) Discuss the validity of the proposed regression model by studying the significance F-value. [3 marks]

(d) Use the regression equation to compute the value of the chosen independent variable value in part (b) if $y = 1000$. [4 marks]

**Continued...**

# APPENDIX A:

| Method | Formula |
|---|---|
| Golden search method | $x_1 = x_R - \left(\frac{\sqrt{5}-1}{2}\right)(x_R - x_L),$<br>$x_2 = x_L + \left(\frac{\sqrt{5}-1}{2}\right)(x_R - x_L).$ |
| Exponential smoothing method | $y^*_{t+1} = \alpha y_t + (1-\alpha) y^*_t$ |
| Holt's method | $L_t = \alpha y_t + (1-\alpha)(L_{t-1} + T_{t-1})$<br>$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$<br>$y^*_{t+k} = L_t + kT_t$ |
| Winter's method | $L_t = \frac{\alpha}{s_{t-c}} y_t + (1-\alpha)(L_{t-1} + T_{t-1})$<br>$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1}$<br>$s_t = \gamma \frac{y_t}{L_t} + (1-\gamma)s_{t-c}$<br>$y^*_{t+k} = (L_t + kT_t)s_{t+k-c}$ |

**End of Paper.**